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behind and downward, then forward and upward, the byssal attachment soon became enclosed in a wide foramen, this extension ultimately reaching the umbones of the larval shell to which it unites. From these facts it will be seen that it presents not even the remotest resemblance to the Brachiopods, but that the young shell has all the proportions of a Bimyarian, and its affinities may be quite remote from Ostrea or Pecten. A study of the early stages of these last named genera would easily settle all these points.

ON EOZOON CANADENSE IN THE CRYSTALLINE LIMESTONES OF MASSACHUSETTS. BY L. S. BURBANK.

THE limestone deposits here referred to, occur in the band of granitic gneiss which extends in a southwesterly direction from near the mouth of the Merrimack river through the entire breadth of the State, and includes the well known mineral localities of Bolton, Boxboro' and Chelmsford.

Soon after the discovery of *Eozoon Canadense* by Mr. Bicknell, in the serpentine limestone of Newbury, it was also identified by Dr. Dawson in specimens collected by me at Chelmsford; as noticed by Dr. Hunt in the "American Journal of Science" for January, 1870. The specimens then examined were not from the rock in place, but were obtained from some outlying masses near one of the quarries. These discoveries led me to make a further examination of several of the old limestone quarries in the same formation. The eozoonal rock was then found in place at several of the quarries, and its position in relation to the other rocks observed.

At all the quarries the limestone has been so thoroughly exhausted, that the limits of its extent at the surface can be readily traced. The relations of the limestone to the enclosing rocks can thus be easily seen.

By the careful study of these relations, and by reference to many specimens collected and facts observed, the following conclusions have been reached.

1. *These limestones are not true stratified rocks laid down with the gneiss, but are subsequent deposits of a vein-like character.* The fact that some of the deposits appear to be interstratified with the gneiss, and also are found along a line apparently coinciding with the strike of the strata, may seem to indicate that

they are parts of original strata included in the gneiss; but their position may also be explained in accordance with another theory, in support of which I shall offer some evidence.

2. *The principal deposits occur along the line of an anticlinal, filling cavities produced by the folding and the falling down of portions of the included strata of the gneiss.* The anticlinal position is most clearly shown at Chelmsford, where there are four veins or masses of the limestone, in two lines coinciding with the strike of the gneiss.

These lines are about half a mile apart, extending in a northeast and southwest direction; the strike, as observed by the compass, being north 65° east. The strata of the gneiss dip in opposite directions from these lines; toward the northwest at an angle of about 65°, to the southeast at an angle varying from about 70° to a nearly vertical position.

The deposits are all of very limited extent, the largest being at the surface not more than two hundred and twenty feet in length, and about sixty feet in width, including the intervening bands of gneiss.

The aggregate length of all the limestone deposits that occur along a line of some twenty-five miles in length, is probably less than one thousand feet.

The vein-like character of the limestone is most plainly shown in one of the abandoned quarries in Chelmsford. The deposits here occur in two principal veins extending in the direction of the strike of the strata to about two hundred feet in length. The structure here plainly shows that cavities which have become filled with the limestone were formed by the folding and faulting of the strata of gneiss. The masses of limestone are separated by strata of gneiss which are also folded and arched over, enclosing cavities filled with the limestone.

At one of the quarries it can be seen that the limestone rested against the irregularly fractured ends of strata of gneiss, which fill a small space in one of the excavations, completely dividing the limestone into two masses.

That the limestone was deposited in cavities mostly closed at the top, which have since been uncovered and exposed at the surface by the denuding action of the drift, seems to me a reasonable deduction from the facts observed.

It is worthy of note that the gneiss of the enclosing walls of the cavities, and that of the dividing bands and the projecting masses nearly enclosed by the limestone, —is all of the same character with that of the surrounding strata not adjacent to the quarry.

In the direction of the strike of the strata also, at a few yards distance from the quarries, the common rock of the region is found with apparently no traces of calcareous matter. In the line along which most of the quarries occur, there are intervals of several miles where no traces of limestone have been found, though the ledges are exposed at the surface in numerous places.

The central and principal part of the mass which filled the veins and pockets and constituted the bulk of the deposit, was *a coarsely crystalline magnesian limestone, homogeneous in structure and showing no traces of stratification.* In examining numerous specimens of this limestone from the different quarries, I have found in it no traces of the eozoonal structure.

The various silicates which form the large number of distinct minerals for which these localites are noted, occur only *attached to, or near, the enclosing walls of the cavities*, and generally in bands or layers, though sometimes irregularly distributed. They are found generally in pretty regular succession. A network of interlacing crystals of actinolite, with smoky quartz, calcite and phlogopite, may be seen attached to the walls; and passing inward there are found pyroxene, scapolite, apatite, boltonite, fine fibrous tremolite, etc.: and also green serpentine in irregular bands or layers, traversed by narrow seams of chrysotile; or scattered through the rock in irregular rounded grains and masses, with intervening spaces filled with calcite.

In these portions of calcite are found the radiating and branching forms that have been identified and described as belonging to the structure of Eozoon. The granules of serpentine are sometimes arranged quite regularly in concentric lines, but more commonly appear irregularly scattered and varying indefinitely in form and size.

Some of the specimens from Chelmsford show masses of the serpentine intersected by narrow seams of chrysotile, and attached to portions of the rock in which the decalcified spaces show the tubuli in great abundance, *attached to the serpentine grains as if growing out from their surfaces.* Some of the grains are surrounded by a fibrous layer, closely resembling the "true cel wall" of Eozoon as I have seen it in the Canadian specimens. The surfaces of many of the grains are covered with acicular crystals penetrating the calcite. Some of these, as they extend into the calcite, become rounded and curved, losing the acicular character.

In nearly all the specimens examined, bundles of acicular fibres, apparently of tremolite, are scattered abundantly in the calcite.

In some portions of the rock the serpentine appears embedded in the limestone in definite crystalline forms, apparently pseudomorphs of chrysolite, or boltonite. In the quarries of Boxboro' and Carlisle, cinnamon garnet is abundant, associated with scapolite and green pyroxene or coccolite, with calcite. I have examined the calcite of many of these specimens for traces of the eozoonal structure, but, so far, with negative results. In fact, so far as I have observed, the tubuli invariably occur in the rock associated with serpentine.

Some facts have been stated in this communication for which I offer no theories in explanation. I do not claim a sufficient knowledge of the Foraminifera to found any argument upon the microscopic appearances that I have observed, nor do I mean now to enter into a discussion of the general question as to the true character of the *Eozoon Canadense*, as described by Carpenter and Dawson.

I am unable, however, to reconcile the facts here stated with the theory that the form in these rocks which have been identified as belonging to the structure of Eozoon, are of organic origin.

On the other hand, it appears to me not unreasonable to infer that the so-called "tubuli" that are so abundant in these rocks, *are semi-crystalline forms that have been deposited with the serpentine and other minerals on the walls of the cavities*, by infiltration of waters charged with mineral matters.

Professor PERRY said:—I desire to bear testimony to the general correctness of the statements made by Mr. Burbank.

In addition to the evidence given by him, I would refer to the fact that the limestones under consideration exactly conform with breaks and other irregularities in the enclosing mass of gneiss. I may also state that in some places calcareous veins which evidently proceeded from the main masses of limestone, may be seen ramifying portions of the walls that form the cavities.

As geologists have generally supposed that all limestones are stratified rocks, a few words may be needful on this point, especially, as serving to meet the objection in this direction which is likely to occur to many minds. Dr. Emmons, as most no doubt are aware, endeavored to show that limestones occur as intrusive masses as well as in stratified beds. Commencing my study of the limestones connected with the foliated series of rocks in the light of this view, I finally became convinced in 1861, and during the same year set forth in a series of lectures, that some of these limestones have a vein-like structure, and should be regarded as true vein-stones.

Such limestones are to be met with in association with the foliated rocks both of eastern and western Vermont, and in various parts of Massachusetts. They also occur among the Adirondacks. Limestones of this character, hand-specimens of which cannot be distinguished by the naked eye from specimens of stratified Silurian limestones, are likewise found in Vermont and elsewhere in the form of dikes. In most of these cases close examination shows that the dike-like masses were formed in the vein-like way by gradual deposition extending from the enclosing walls toward the centres of what once were cavities. Similar masses of calcareous vein-stone are to be met with in St. Lawrence County, N. Y., and in some other places, penetrating beds of sandstone.

These, and similar cases which might be readily cited, are suited to remove the objection that limestones are always stratified rocks. At the same time the occurrence of undoubled *Eozoon Canadense* in calcareous vein-stones of eastern Massachusetts tends not only to disprove the animal origin of the specimens from the localities under consideration, but also to involve in doubt the organic character of the Eozoon generally.

ON THE EOZOON LIMESTONE OF EASTERN MASSACHUSETTS. — BY PROF. J. B. PERRY.

HAVING about ten years ago, made out that some of the limestones associated with the foliated rocks in Vermont and New York, are vein-stones, I have ever been skeptical in regard to the supposed organic nature of the Eozoon. As I had more recently satisfied myself that limestones in Stoneham, Newbury, and several other places in eastern Massachusetts are also vein-rocks, I at once, on the announcement of the discovery of Eozoon in the limestones of Newbury, discredited its assumed organic character, on the ground of its occurrence in calcareous masses of a vein-like origin. On hearing of a like discovery in Chelmsford, and seeing a specimen, I had a similar conviction; and this I immediately expressed in one of the lectures which I was then delivering in course, and was able fully to confirm by personal examination, on visiting the quarry a few months later, in company with my friend Mr. Burbank, of Lowell, who had before and has since